Do central banks rebalance their currency shares?

Menzie D. Chinn*
University of Wisconsin, Madison and NBER

Hiro Ito**
Portland State University

Robert N. McCauley***
Boston University and Oxford University

May 2, 2021

Abstract

Do central banks rebalance their currency shares? We explore this question by using different types of datasets from the global aggregated level, the country-level, and a panel context. At the disaggregate level, we find a mixed bag; some economies do rebalance while others do not. However, our casual analysis show that the US does not rebalance. Switzerland, a no-G3 advanced economy, does seem to rebalance FX reserves. Its currency composition is independent of the dollar exchange rate movements. We also explore the question of rebalancing with a panel data analysis and find that our sample economies on average do not rebalance. Emerging market economies (EMEs) do not rebalance and advanced economies do rebalance. Larger economies maintain stable currency composition while smaller economies have their reserves more vulnerable to exchange rate shocks.

JEL No. F32, F41

* Robert M. La Follette School of Public Affairs; and Department of Economics, University of Wisconsin, 1180 Observatory Drive, Madison, WI 53706, USA, and NBER; e-mail: mchinn@lafollette.wisc.edu
** Department of Economics, Portland State University, SW Broadway, Cramer Hall 241, Portland, OR 97201: e-mail: ito@pdx.edu.
*** Global Development Policy Center, Boston University, and Senior Research Associate, The Global History of Capitalism project, Oxford Centre for Global History, University of Oxford; e-mail: robertneilmccauley@gmail.com.

Acknowledgements: Chinn and Ito acknowledge the financial support of faculty research funds of the University of Wisconsin and Portland State University, respectively.

1. Introduction

Do central banks rebalance their currency shares? Or, should they? Does the size of reserves, the transparency of the reserve portfolio, or the existence of a currency board matter for the answers? Do or should central banks rebalance less when strains hit financial markets?

Reserve managers must answer such questions when the dollar (USD) moves against the euro, the yen, the pound, the Swiss franc, the Canadian and Australian dollars, and now the renminbi. Yet economists have paid scant attention to these questions even as reserve holdings exploded in the 2000s. A rare exception, Blanchard et al, (2005) resurrected 1970s portfolio balance theory to analyze a possible shift from the dollar by China's reserve managers (Lu and Wang, 2019). But what is the baseline from which such a momentous shift should be measured?

Instability of private portfolios became the subject of Kindleberger's (1937) thesis, the theme of Nurkse (1944), and the elephant in the room ignored by proponents of floating currencies (Friedman,1953, 1968; Johnson, 1969). Between the World Wars, Młynarski (1929) warned of instability in *official* currency allocations; Eichengreen and Flandreau (2007) demonstrated such instability in the 1930s. Triffin (1960) updated Młynarski's warning for Bretton Woods, pointing to the instability of its dollar-gold link (Bordo and McCauley, 2019). Sterling's decline subsequently demonstrated such instability (Schenk, 2003). Proponents of a substitution account in 1979-80 sought to manage reserve managers' shift out of the dollar by replacing dollars with International Monetary Fund (IMF) Special Drawing Rights (SDRs; McCauley and Schenk, 2011).

We follow Williams (1934, 1937, 1944) and Kindleberger (Mehrling, forthcoming) in distinguishing the behavior of key-currency central banks from that of their 100+ counterparts. The Fed, the Euro-system, and the Bank of Japan hold official foreign exchange (FX) reserves and swap their currencies to manage the system, both exchange rates and wholesale funding liquidity.

For the rest, liquidity considerations may constrain reserve managers to hold mostly dollars

to match the vehicle currency in the largely private spot FX market (BIS, 2019). In all but Japan, the United Kingdom, Switzerland, Sweden, Denmark, Norway, Poland, Hungary and a handful of other European countries, the authorities have little choice but to intervene using the dollar.

But as reserves grow, central banks tend to come to the view that they represent a portfolio to be managed as such. Reserves are often split into liquidity and investment tranches (Borio et al., 2008; Schanz, 2019). Means-variance optimization and eclectic methods guide the latter's allocation (Frankel, 1985; Ramaswamy, 2008). Depending on central bank transparency and governance, reserve managers report and defend their currency allocations to senior management, the central bank board, the legislature or the public (Johnson-Calari and Strauss-Kahn, 2020).

FX moves typically do not change whatever reasoning produced an allocation deemed optimal. Chinn and Frankel (2005) argue that rebalancing flows from means-variance optimisation and should be taken as the norm. The exception would be elastic expectations, which extrapolate from a strengthening dollar that it is likely to strengthen more. Given long dollar swings (Engel and Hamilton, 1990; Kreicher and McCauley, 2021), such expectations cannot be dismissed out of hand. A reserve manager judged on annual results might not safely assume a random walk.

Central bank rebalancing deserves more attention for three reasons. First, FX reserves now stand at $12.7 trillion; the management of such a large portfolio should interest policymakers, academics and financial market participants. The implications for FX rates of equity rebalancing by private portfolio managers has received much attention. Hau and Rey (2006), Cappiello and De Santis (2005, 2007) and Camanho et al. (2020) posit that global investors rebalance symmetrically in response to own-currency equity gains and currency gains. However, Curcuru, et al. (2014) find that US investors do not stabilise FX rates by rebalancing after FX movements. Recognising widespread currency hedging of cross-border equity holdings (Borio et al., 2017), Melvin and Prins (2015) show that equity gains lead index-tracking investors to maintain their hedge ratios by

simultaneously selling the currency forward at the 4pm "London fix" at end-month, depreciating it. To our knowledge, this is the first study of reserve managers' currency rebalancing.

Secondly, rebalancing can stabilise key FX rates. When the dollar rises, do central banks sell it? When the dollar falls, do central banks buy it? If so, they counter the widespread momentum-following FX strategy of leveraged commodity ("CTA") funds and others (Neely et al. 2009; Menkhoff et al., 2012: Moskowitz et al., 2012; Ivanova, et al. 2021). Pihlman and van der Hoorn (2010) argued that central banks' instrument choice (not currency choice) was procyclical around the 2008 Great Financial Crisis, as central banks withdrew deposits from banks in a flight to quality to US Treasury securities.[1] The issue of whether central banks damp or contribute to market swings is important.

Third, rebalancing matters because it means that a depreciating dollar can provide support to the US Treasury market, where issuance is heavy and the Fed is currently buying $80 billion a month in response to recurring strains (Liang and Parkinson, 2020). Consider the possibility that the US dollar has switched from its long upswing from 2011 in 2020 to a downswing (Engle and Hamilton, 1990; Chinn, ; Kreicher and McCauley, 2021). In a dollar downswing, if central banks rebalance, then they buy dollars. Once they have bought dollars, the modal investment is US Treasury notes, especially at intermediate maturities ("the belly of the curve", Gerlach-Kirsten et al., 2016; McCauley, 2020). The importance of official buying and selling to US bond yields is the subject of many studies (eg Bernanke et al., 2004; Backus and Wright, 2007; Warnock and Warnock, 2009; Gerlach-Kristin, et al., 2016; McCauley, 2017). Just as dollar depreciation lightens the US external debt (Tille, 2005), it draws official foreign investment into US bonds.

[1] McCauley and Rigaudy (2011), using BIS international banking data, find that reserve managers' retreat from risky banks started with Swiss banks in 2007 and was spread over quarters, as opposed to US money market funds' run on non-US banks in the days and weeks after the Lehman Brothers failure, as described by Baba, et al., (2009). See McCauley and McGuire (2009) for the flight to quality in US Treasury bills in late 2008.

A back-of-the-envelope calculation underscores rebalancing's potential. Assume the dollar depreciates by 10% against the euro, the yen, sterling and the renminbi.[2] At end-2020, US dollar reserves stood at about $7.5 trillion and non-dollar reserves stood at about $5.7 trillion equivalent.[3] A 10% dollar depreciation against this basket of reserve currencies would thus add about $570 billion to reserves. For the dollar to retain its 59% share, over $300 billion would need to be shifted into the dollar.[4] Is this a big number? It is almost half the 2020 US current account deficit of $647 billion, 3.1% of GDP. It approaches in size the massive Japanese intervention of 2003-04 (Gerlach-Kirsten et al., 2016). Regarding the possible effect on US Treasury bond yields, the just-cited papers tend to find that $1 billion of inflow into US Treasury bonds was associated with a one basis point decline in their yields. Who knows how persistent such an effect might be? Still, the strong suggestion is that rebalancing could support a Treasury bond market challenged by heavy supply and recurrent strains in market-making, breadth, depth and liquidity.

We examine several factors that may shape reserve managers' response to FX changes:

- **Regime:** A currency board like Hong Kong may feature a backing portfolio in the currency of the link (ie $) that is not subject to rebalancing, so rebalancing is at most partial.
- **Scale of FX reserves**: Larger reserves are likely to be managed as an endowment rather than as a liquid pool (even if there are matching interest-bearing liabilities). Optimisation and rebalancing become more likely with larger size (Beck and Weber, 2011).
- **Size of FX reserve changes**: On the upside, reinvestment from the intervention currency (usually the dollar) into other key currencies may lag, boosting the intervention currency's share.[5] On the downside, use of reserves requires buying the intervention currency with

[2] A 10% depreciation in a year is big, but peak-to-trough dollar downswings entail multiple such moves.
[3] We use identified FX reserves in the COFER data to allocate the unidentified ones between dollar and non-dollar.
[4] In practice, dollar reserve accumulation quickens during a dollar downswing (Bordo and McCauley, 2019, Table 1), so the rebalancing could be done by simply not shifting freshly bought dollars into other key currencies.
[5] See Gerlach-Kristen et al. (2016) on the similar lag between the Japanese Ministry of Finance (MoF) buying dollars

other key currencies, and this too may lag, reducing the intervention currency's share.

- **Market volatility:** If reserve managers seek to rebalance without the order flow's disturbing key FX rates (eg dollar/euro), then strained markets may inhibit or at least slow the rebalancing (Fischer et al., 2021).[6] Think 2008Q4 or 2020Q1.
- **Dollar trend**: A long dollar upswing (Engle and Hamilton, 1990; Kreicher and McCauley, 2021) may lead to a larger dollar weight in the strategic asset allocation, as reported for the Reserve Bank of India during Governor Rajan's tenure in 2015 (Sarin and Singh, 2015). Such a choice may be more likely when euro yields are negative, given the reserve manager's capital-preservation mandate (Borio et al., 2008; Schanz, 2019).[7] Letting dollar appreciation set the pace for a higher strategic weight on the dollar is observationally equivalent to not rebalancing.

The main findings of this paper are four. First, the key currency perspective does not mislead: at least one of the G3 central banks[8] does not rebalance, consistent with its role as manager rather than participant in the international monetary and financial system.

Second, we find a mixed bag at the aggregate level. While an appreciating dollar does significantly raise the USD share in FX reserves, the rise is also significantly less than what would find if no central bank were rebalancing. In other words, some central banks reporting in the IMF currency composition of official FX reserves (COFER) database rebalance and some don't.

Third, major non-G3 reserve holders tend to rebalance FX reserves. This behaviour

and its investing them in US Treasury securities.

[6] Or central banks may follow the advice of Harvey et al. (2021) and not rebalance in volatile markets if exchange rate changes are perceived to have momentum, so that delaying rebalancing is profitable.

[7] By the same token, in a long dollar downswing, a big reserve holder whose diversification could move dollar/euro (Blanchard et al., 2005) may do so opportunistically by not rebalancing.

[8] For ease of exposition, we shall write as if FX reserves are held in central banks. In fact, the Japanese MoF holds almost all of Japan's $1 trillion in FX reserves and the US Treasury and the Fed split US FX reserves more evenly. An interesting question is how various institutional arrangements affect rebalancing behaviour; we do not address it..

stabilizes key FX rates as the appreciating currency is sold in favor of the depreciating one.

Fourth, many emerging market economies (EMEs) do not rebalance but the big holders do.

The rest of this paper is in four parts. Section 2 profiles two well-reported FX reserve managers, the US Treasury and Fed and the Swiss National Bank (SNB; Streit and Muhl, 2020), the former not at all rebalancing, the latter rebalancing. Section 3 analyses aggregate rebalancing, using the IMF COFER database. Section 4 reports a panel analysis of more than 50 countries using the dataset of Ito and McCauley (2020). Section 5 concludes.

2. Case studies with rich data – US and Swiss reserve management

We start our analysis on whether central banks rebalance or do not rebalancing by focusing on two country case studies. Both the US and Swiss central banks disclose detailed information regarding their FX reserve portfolios on a quarterly basis. The United States serves as a usefully pure case of no rebalancing, Switzerland, although more complicated, serves no less certainly as a case of rebalancing.

3.1 US reserve management

Federal Reserve Bank of New York (FRBNY) reports the composition of US FX reserves every three months in USD. Since 2000, the US intervened in the FX market only once after the Tohuku Earthquake in Japan, selling $1 billion equivalent of yen in a concerted action with the Japanese Ministry of Finance, the ECB, the Bank of Canada, and the Bank of England. Thus, apart from a vanishing trickle of interest receipts, the quarterly variation in the dollar value of US FX reserves held in euro and yen arises from valuation effects.[9] US reserves rise when the dollar

[9] In its most recent report for Q4 2020, FRBNY (2021, p 15) ascribes the changes in euro holdings of $1.1 billion and yen holdings of $0.4 billion, as usual, to FX rate changes: "These changes are largely driven by foreign exchange translation effects" in the context of a depreciating dollar. Below we exclude FX holdings arising from FX swaps, which is easy to do using the quarterly reports' regular table, "Breakdown of foreign reserve assets held", since these remain in the reciprocal nostro accounts and are not invested in government securities, BIS deposits or the like (Potter

depreciates against the euro and yen, and fall when the dollar rises against them.

Such translation effects, however, are not restricted to the USD value of the foreign currencies. There are also important shifts in this US case in the value of the euro against the yen. Without a response by the US authorities, changes in this cross-rate shift the euro and yen shares of US FX reserves. For instance, if the yen rises against the euro, absent any response, the yen gains weight in US reserves. It is this valuation effect that this paper addresses.

If one uses end-quarter rates for the close in New York (admittedly these Datastream data do not exactly match the FRBNY's use of noon New York rates to value its portfolio), to convert the dollar amounts reported by the Fed into euro and yen, it is clear that the US authorities do not rebalance. The lines in Figure 4(a) gently slope in reflection of interest receipts (/costs), with the exception of the aforementioned drawdown in yen in March 2011. The evolving euro/yen exchange rate, not the managers in New York and Washington, set the pace for the change in shares.

The point that the US authorities do not rebalance is already well demonstrated, but one more graph helps to set up our subsequent analysis. Figure 1(b) shows the euro share of US reserves from end-2000 to end-2020 (excluding holdings of various currencies that result from FX swaps, which remain as correspondent bank deposits in the counterparty central bank).

It is evident that the euro share moves around quite a bit, as a consequence of basically static holdings of euros and yen and an evolving cross-rate between them. In the 20 years, the euro peaked against the yen at 168 yen per euro in June 2008, and troughed at 99 yen per euro just four years later in June 2012, in the wake of the European sovereign debt crisis. In June 2008 the US reserve portfolio comprised 63.8% euro and 36.2% yen. In June 2012, it comprised 53.9% euro and 46.1% yen. To repeat, the US authorities do not rebalance despite big swings in the euro/yen.

---

et al., 2020).

Figure 1(c) plots the observed euro share again and now also the change in the share based on the previous quarter's quanta of euros and yen and the actual exchange rate change. The dashed line cumulates these changes. This tracks the observed ratio very well except in March 2011. If the US authorities had religiously rebalanced, however, we would observe the flat dotted line.

The upshot is that US reserve management is well characterised by the dashed line and not at all by the dotted line. The US practice of not rebalancing in response to changes in the euro/yen exchange rate allows changing exchange rates full play to alter shares; by contrast, rebalancing them would offset euro/yen rate changes fully.

When we move to other non-G3 cases, such as next up Switzerland, the main currencies are not euro and yen but rather dollar and euro, which together make up about four-fifths of all FX reserves. A complication is that central banks that do rebalance may also irregularly shift their strategic asset allocations to raise or to lower the dollar share. The SNB is so transparent that we can insert dummies to capture these re-weightings, so that the degree of rebalancing in other, more normal quarters can be assessed econometrically. However, this is possible for neither the aggregates nor the panel analysis. The danger, for instance, is that there is a positive relationship between the dollar's appreciation and reweighting in favour of the dollar (the elastic expectations case). In this case, we might misinterpret a re-weighting as a lack of rebalancing.

3.2 Swiss reserve management

Turning now to Switzerland, Figure 2 illustrates the development of the major currency shares in SNB's FX reserves from 2005Q1 through 2020Q4.[10]

[10] From the SNB's website, we use the data "Foreign currency investments, including derivatives, excluding foreign exchange swaps for monetary policy purposes." There is another data series called "Foreign currency investments, excluding foreign exchange derivatives" and its time series starts in 1997Q1. However, the latter include spot positions in the dollar and euro that result from swaps done for monetary policy purposes. In particular, faced with a small domestic money market but a large FX market, the SNB often swaps CHF against USD to provide domestic bank reserves. This increases its holdings of USD, but not its USD exposure. Thus, of more interest from a reserve management perspective are the SNB's FX holdings excluding swaps.

Interestingly, the share of the USD appears to be roughly stable from 2005Q1 through 2015Q1, hovering 26-28%, though there are two spikes down, one in 2010Q1-Q2 when the Greek debt crisis broke out and the other in 2012Q2 before ECB President Mario Draghi promised to do "whatever it takes" on 26 July 2012. In the beginning of 2015, after the SNB ended the exchange rate cap of the Swiss franc against the euro in an environment of dollar appreciation, the SNB boosted the USD share gradually rises, getting closer to 40%. For the last five years, it is stabilized around 35-37%.[11]

In the analysis below we dummy out four quarters when the SNB changed its strategic asset allocation by currency:

1. 2010:1 "Five new investment currencies were added: the Australian dollar (AUD), Singapore dollar (SGD), and Swedish krona (SEK) in 2010" (Streit & Muhl, 2020, p 237)
2. 2010:3: "The share of the main investment currencies, the US dollar and the euro, fell slightly [from 30% and 58% in Table on p 66] to 25% and 55% respectively, while the shares of the Canadian dollar and Japanese yen rose". (SNB, 2011, p 68)
3. 2015:1: "in 2015 the Chinese renminbi (CNY)" (Streit & Muhl, 2020, p 237)
4. 2017:1: "The euro share declined slightly in favour of the US dollar; the shares of the other currencies remained unchanged" (SNB, 2018, p 84).

How do the SNB reserve managers respond to movements in the key currency exchange rates? We examine the impact of the exchange rate movements on the share of the USD

We construct a variable called Val_Eff_{USD}, which represents the pure valuation effect of the dollar. The USD share in FX reserves changes depends on both the movements of the dollar's

[11] The EUR share presents a mirror image. It peaks at 70% in 2010Q1 and again at 60% in 2012Q1, after which, however, the EUR share consistently falls. For the last few years of the sample, it marks around 40%. SNB reports the shares of JPY, GBP, and CAD, but as was in the case of the aggregate picture based on the COFER dataset, none of these currencies appear to be a third dominant currency.

exchange rates against other currencies and the change in the quantity of reserves in different currencies. The valuation effect on the dollar share can be expressed as follows:

$$Val\_Eff_{USD}^{SNB} = \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_C^C \frac{\mathrm{R}_C(\mathrm{t}-1)}{FX_C(t)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_C^C \frac{\mathrm{R}_C(\mathrm{t}-1)}{FX_C(t-1)}} \qquad (1).^{12}$$

R_c is foreign exchange reserves in major currency *c,* which we obtain from the SNB's database. That is, R_{USD} is FX reserves in USD, R_{JPY} is FX reserves in the Japanese yen, and so forth. Non-USD reserves, $R_{c,c\neq USD}$, needs to be converted to USD by using the exchange rate of currency *c* per dollar. Hence, $\frac{\mathrm{R}_c(t)}{FX_c(t)}$ is the holding of FX reserves that is denominated in *c*, as expressed in USD at the current exchange rate. In equation (1), while the first term values last period's holdings $R_{USD}(t\text{-}1)$ and $R_c(t)$ at the current exchange rate $(FX_c(t)))$, the second term values the same holdings at the previous period's exchange rate $(FX_c(t-1))$. We are only interested in the valuation effect that results from exchange rate moves, so we keep the quantum of reserves in each major currency *c* in its local currency constant. By subtracting the previously observed USD share (the second term in equation (1)) from the calculated USD share that only incorporates the exchange rate change (not any change in the quantum of the reserve currencies), we obtain $Val\_Eff_{USD}^{SNB}$.

We regress the USD share on $Val\_Eff_{USD}^{SNB}$ as below, and report the results in Table 1.

$$\Delta \boldsymbol{y_t^{USD}} = \alpha + \boldsymbol{\beta Val\_Eff_{USD,t}^{SNB}} + X'_t\Gamma + \varepsilon_t \qquad (2)$$

The estimation results suggest that rebalancing is very much the norm at the SNB. The

[12] More generally, the valuation effect of major currency *c* is: $Val\_Eff_c^{SNB} = \frac{\frac{R_C(\mathrm{t}-1)}{FX_C(t)}}{\sum_C^C \frac{\mathrm{R}_C(\mathrm{t}-1)}{FX_C(t)}} - \frac{\frac{\mathrm{R}_C(\mathrm{t}-1)}{FX_C(t-1)}}{\sum_C^C \frac{\mathrm{R}_C(\mathrm{t}-1)}{FX_C(t-1)}}$.

coefficient on the constructed valuation change is consistently insignificant. Rapid growth of the SNB's reserves is associated with a lower dollar share (second row).[13] This finding is consistent with the SNB's intervening in the spot FX market to buy euro and then rebalancing by buying dollars only with a lag. In particular, if the SNB sought to minimise the effect on the euro/dollar rate of such rebalancing, it could have adopted the latest trading technology of using algorithmic trading to dribble orders into the automated interbank brokerage platform, EBS. But this would introduce lags, especially if euro-buying were heavy at end-quarter. The upshot would have been a positive association of very rapid growth of Swiss reserves and the euro share, and a corresponding negative association between growth and the dollar share.

Stepping back, the contrast between the US and Swiss reserve management in the face of exchange rate changes could hardly be more stark. The US Treasury and Fed hold a certain number of euros and yen and, scant interest earnings aside, hold them from quarter to quarter. This means that the share of euro and yen in the US reserve portfolio drifts with the euro/yen exchange rate. By contrast, the SNB has (varying) targets for the dollar and euro portions of its FX reserves. Exceptional growth in those reserves apart, it serves as a source of stability in the FX market by selling a rising dollar and buying a falling dollar.

How does the aggregate of FX reserve management fit in between these two polar cases? Section 3 attempts to answer this question.

3. The big picture of global reserve management –rebalancing or not?

We now focus on an overview of the use of major international currencies as reserve currencies, based on aggregate IMF (composition of foreign exchange rates: COFER) data. Figure

[13] The negative effect of the growth rate of the SNB's reserves is greater when the valuation effect is greater (third row).

3 shows that the dollar remains the dominant reserve currency, followed at a distance by the euro. From 1999 through 2011, the USD share showed a moderately declining trend, falling from 72% to about 60%. The share rose in 2014 and fell again from 2017.[14] The development of the EUR share has not quite mirrored that of the USD share. The EUR share showed a moderately rising trend from the beginning of the sample period, rising from less than 20% to 28% up to 2010. Then the sovereign and bank crisis erupted in the euro area, driving down the share. It then bottomed out in 2015 at about 20%. The JPY and GBP come in a distant third and fourth, with shares hovering below 5%.

Figure 4 repeats the shares of USD and EUR in solid lines, and also shows their shares without the valuation effects in broken lines. That is, the USD and EUR shares are recalculated using exchange rates of all as of 1999Q1. Purged of the valuation effects, the two shares are more stable than the observed currency shares that incorporate the exchange rate movements. On this showing, it is hard to argue that central banks in the aggregate rebalance their currency shares.

An intriguing asymmetry emerges when the sample is split into the long downswing of the dollar in the 2000s and the long upswing in the 'teens. The US dollar nominal effective exchange rate (US-NEER) in Figure 5(b) shows a long dollar downswing from 2002Q1 to 2011Q3, and a long upswing from 2011Q3 to 2020Q2. For the whole sample, the regression of the USD shares on a time trend results in a steeper estimated decline for the USD share with valuation effects than for the share without them (Table 2, columns (1) and (2)). But in the downswing, reserve managers allowed the dollar's decline to lower their USD share at current exchange rates: column (3) shows a declining trend, but once the valuation effects are removed in column (4), the USD share is constant. The finding that the observed USD share (with valuation effects) trended down when the

[14] Observations starting in 201 contain a growing proportion of Chinese reserves, but the order of entry of these data may have favoured some reserve currencies over others, making the aggregates for a number of years noisy. See Hauck and Truman, 2015.

dollar was in a depreciation trend indicates that, in the aggregate, reserve managers were at most partially rebalancing their portfolio, and letting the USD share fall instead.

In aggregate, however, reserve managers did not sit on their hands when the dollar switched to an upswing. During the 2011Q3 – 2020Q2 dollar upswing, the dollar share remained statistically constant (column (5) of Table 1), while the USD share without evaluation effects showed a declining trend. That the USD share with valuation effects remained constant while the dollar was in an appreciating trend suggests that reserve managers were rebalancing to maintain the constant USD share. Reserve managers look to have allowed the depreciating dollar to take their dollar weights down but then resisted a symmetric rise in their dollar weights with an appreciating dollar.

Passing from analysis of broad trends to quarter-by-quarter changes, we examine how the valuation effect, $Val\_Eff_{USD}^{COFER}$, affects the observed USD share from the COFER database by regressing the latter on the former as follows:

$$\Delta \boldsymbol{y_t^{USD}} = \alpha + \boldsymbol{\beta Val\_Eff_{USD,t}^{COFER}} + X'_t\Gamma + \varepsilon_t \qquad (3)$$

Some reserve managers might tolerate currency shares moving within a broad band, and regard rebalancing as a decision that might have to be defended if an exchange rate trend were to prove persistent. Others might take rebalancing as the norm "[b]ased on the theoretical and empirical findings of modern portfolio theory (MPT) and a reflection on the principles and practices of professional portfolio management techniques" (Streit and Muhl, 2020, p 227).

If the estimated coefficient on $Val\_Eff_{USD}^{COFER}$ is found to be one, then reserve managers eschew rebalancing and let the USD reserve share follow exchange rate movements one-to-one. In contrast, if the estimated coefficient is found to be zero, reserve managers actively rebalance to maintain the USD reserve share constant.

The estimation results reported in Table 3 show that the estimated coefficient of $Val\_Eff_{USD}^{COFER}$ across different models is significantly positive, but less than one. When the null hypothesis of $\beta(VE)$=1 is tested, it is rejected at statistically significant levels in all cases but Model 3, indicating that the estimate of the valuation effect variable is less than one.[15] That means that overall, reserve managers partially rebalance. This aggregate finding may reflect the average response across reserve managers, some of which rebalance and others which do not.

We also test the growth rates of total reserve assets net of the exchange rate effects.[16] Its estimate is found to be significantly positive. When the reserve portfolio grows rapidly, the USD share rises. This may result from the fact that, for most countries, the USD is the intervention currency, the vehicle currency in the spot market in which the authorities can operate. If, in addition to this vehicle currency role of the dollar, rebalancing into other key currencies takes time, then reserve growth can lead to a perhaps temporarily higher dollar share. Symmetrically, a rapid drawdown of reserves may lower the dollar share as sales of reserves take place against the dollar and lags intervene between such sales and rebalancing from other key currencies into the dollar.

In model 3, we test whether there is any interactive effect between the value effect variable and the growth rate of the reserve portfolio, and find the estimate is significantly negative. That indicates that the valuation effect positively affects the USD share in FX reserves, but its impact is smaller when the reserve portfolio is expanding rapidly.

When the economy of concern faces economic uncertainty, the respective central banks' reserve managers may decide to make reserves more immediately useful for intervention (or to lend to banks) and thus to hold more USD-denominated assets. If that is the case, financial

[15] The p-value is reported at the bottom row of the table.

[16] "Total reserve assets" are "allocated reserves in dollars" in the COFER database. The way of removing the valuation effects is analogous to equation (1). Here, instead of maintaining the volumes of local currency reserves constant, we hold the exchange rate constant over the consecutive quarters and let the local currency reserves vary.

instability can lead to a higher USD share. The correlation between the USD and our proxy for financial instability, the VIX index, is then predicted to be positive.

In model 4, we include the natural log of VIX in the estimation. Its estimate is found to be positive, but not statistically significant while the estimate on $Val\_Eff_{USD}^{COFER}$ is still significantly positive. In model 5, we test if there is any interactive effect between the VIX and the value effect variable, and find the interactive effect is significantly positive. The valuation effect is stronger when there is global financial instability. It is as if disturbed conditions in financial markets leads to less active trading to maintain target currency shares.

Recall the intriguing asymmetry in Figure 5. When the dollar was in a depreciating trend from 2002 to 2011, reserve managers allowed their USD shares to fall with the depreciation trend. From 2012 to 2020, however, reserve managers in aggregate (although reportedly not at the Reserve Bank of India) resisted the dollar appreciation, rebalancing to keep their USD shares stable. Model 6 includes the dummy for the subsample periods of 1997Q1-2002q1 and 2011Q3-2020Q1, in both of which the dollar appreciated other key currencies. We test this more formally and find that when the dollar appreciates, the USD reserve share tends to be higher, but the impact is not statistically significant (column (6)). In column (7), we interact the dummy variable with $Val\_Eff_{USD}^{COFER}$; that does not yield a significant estimate for the interaction term.

4. Testing the valuation effects on the USD share in the panel context

We have found partial rebalancing for the global aggregate and full rebalancing for Switzerland. Naturally, not only does the motivation for holding foreign exchange reserves differ across central banks, but the preferences for reserve currencies should vary across countries. We now analyse the relationship between valuation effects and dollar shares in annual data across individual countries.

We build on Ito and McCauley (2020), who investigated the determinants of the shares of major currencies in FX reserves This work added about 30 countries to previous work done on individual country data (Truman and Wong, 2006; McCauley and Chan, 2014; Ito et al., 2015; Gopinath and Stein, 2018a,b) and reduced the European bias in the earlier work. This work has been joined a paper by Iancu et al. (2020) from the IMF Strategy, Policy and Review Department and the Statistics Department, which claims (p 19) "a novel database of individual economies' reserve currency by currency".[17] The COFER data are reported for either the entire world, the group of industrialized economies, or that of emerging and developing economies, but not for individual countries except for some consenters.[18]

Here, we test the impacts of exchange rate fluctuations on the currency composition in a panel data setting. For that, we first construct the valuation effect variable, $Val\_Eff_{USD}^{IM}$, by using the Ito-McCauley dataset and estimate the impact of $Val\_Eff_{USD}^{IM}$ on the first-difference of the USD shares in FX reserves for 56 countries over the period of 2001 through 2018.

Our sample does not include the US, Japan, or the euro member countries. To control for time invariant factors that may affect the currency composition, we include the country fixed effects in the estimation model.

First of all, the estimate on the valuation effect is significantly positive except for models

[17] The most generous interpretation of this claim in a paper published on 17 November 2020 (https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2020/11/17/Reserve-Currencies-in-an-Evolving-International-Monetary-System-49864) is the following. None of the nine authors, neither of their two colleagues who provided overall guidance, neither of another two colleagues who provided sponsorship and support and neither of yet another two colleagues who provided support and collaboration in a companion project, 15 altogether, saw either the JIMF conference programme at which Ito and McCauley (2020) was originally presented in May 2019 (https://www.cb.cityu.edu.hk/ef/doc/GRU/JIMF%202019/program_20190519.pdf), or the online version of the JIMF publication, copyrighted 2019 and available online on 18 November 2019, or the 13 December 2019 BIS Working Paper (https://www.bis.org/publ/work828.htm), or the 9 June 2020 FLAR Webinair (https://www.flar.net/en/webinar/flar-webinar-currency-composition-foreign-exchanges-reserves-prof-hiro-ito-robert-mccauley). This interpretation requires 60 missed opportunities, and only 15 of them arrived after the outbreak of COVID-19.

[18] Heller and Knight (1978), Dooley et al (1989), and Eichengreen and Mathieson (2000) have used individual countries' confidential data from the COFER database.

(7) and (8) (Table 5), with its coefficient ranging around 0.76 to 0.96 and statistically no different from the value of one in most models. That is, *on average,* the impact of the exchange rate movements fully passes through to the USD share in FX reserves with a 1:1 ratio at the annual frequency.

The growth rate of the portfolio (net of the valuation effect) positively affects the USD share, again suggesting that when the portfolio expands, the volume of USD reserves disproportionally increases, making the USD share rise. Again, this can be interpreted as reflecting the dollar's vehicle currency role in the spot market *and* lags in the rebalancing.

We also test other variables such as the percentage point change in VIX, its interaction with the valuation effect, FX reserves minus gold (as % of GDP), and interaction term with the valuation effect. However, none of these variables enter the model significantly.

We test whether the size of the economy affects reserve rebalancing by running a weighted regression using purchasing power parity-based GDP shares of the world total. In this weighted regression in model (8), the estimate on the valuation effect now becomes insignificant. This finding suggests that larger economies tend to rebalance their portfolio and maintain its currency composition stable, and the unweighted regression is dominated by smaller economies that do not rebalance.

To test for possible heterogeneity across countries, we divide the full sample into the subsamples of advanced economies (AEs) and emerging market economies (EMEs).[19] In columns (1) and (2) of Table 5, we see that among AEs, reserve managers neutralise the effect of FX movements on their currency composition. These central banks thus buy and sell key currencies as needed to stabilize their portfolio shares. In contrast, the estimate on the valuation effect for the

[19] Country grouping is based on the definition by the IMF.

EMEs is significantly positive, and also, it is not statistically different than the value of one. This finding suggests that EMEs' do not rebalance.

Interestingly, the estimate coefficient on the growth rate of reserve portfolio is significantly positive for EMEs, but significantly negative for AEs. EME and AE may be proxying for geography and thus for the role of the dollar and euro as vehicle currencies. EMEs listed in Appendix 2 include many Latin American countries and Asian economies whose currencies trade overwhelmingly against the dollar in the spot FX market. In contrast, the AE group comprise many large European economies whose currencies trade against the euro as the vehicle currency in the spot market, such as Denmark, Norway, Poland, Sweden, Switzerland, and the UK. Clearly, we need to investigate the influence of the vehicle currency directly.

Lastly, we divide the full sample between commodity exports and non-commodity exporters and examine whether there is any difference between the two subsamples in the way in which exchange rate movements affect the currency composition. We find that the estimate of the valuation effect of the commodity exporters is greater in magnitude than that of the non-commodity exporters, though we find the difference is not statistically significant.

5. Concluding remarks

How do reserve managers respond to exchange rate movements? It sounds like a simple question, but no one seems to have asked it, owing in part to the difficulty in assembling the data. By using different types of data, we explore the question of how central banks' reserve managers respond to exchange rate movements. Plainly, we focus on the question of whether central banks' reserve managers rebalance their currency shares or not. The main findings of this paper are four.

First, the US, one of the G3 economies, does not rebalance, consistent with its role as manager rather than participant in the international monetary and financial system. It lets its

foreign exchange portfolio fluctuate and reflect exchange rate (e.g., the euro-yen exchange rate) movements. The behaviour of the Japanese authorities remains to be investigated. The behaviour of the Eurosystem, where only a small fraction of reserves has been centralised, is probably as diverse as is challenging to analyse.[20]

Second, we find a mixed bag at the aggregate level. Our regression analysis with the COFER data suggests that countries conduct partial rebalancing on average. While an appreciating dollar does significantly raise the USD share in FX reserves, the rise is also significantly less than what would find if no central bank were rebalancing. In other words, some central banks reporting in the IMF COFER database rebalance and some don't.

Third, many emerging market economies (EMEs), particularly smaller ones, do not rebalance. FX movements change the USD share in their FX reserves one-to-one.

Fourth, major non-G3 reserve holders tend to rebalance FX reserves. We examine the case of Switzerland's reserve management and find SNB's reserves do not react to the dollar exchange rate movements. The SNB nullifies the impact of FX movements on its reserve portfolio by rebalancing the currency shares in its reserves. We also find that larger economies, and presumably larger reserve holders rebalance. This behaviour stabilizes key FX rates as the appreciating currency is sold in favor of the depreciating one. Our back of the envelope calculation suggests that this effect could be macroeconomically significant.

Looking forward, a next step is a weighted regression where reserve holdings are used for the weights, along with an analysis of the effect of the vehicle currency in the spot market, particularly in the context of rapid reserve growth. Lags also need to be investigated, at least for central banks that publish quarterly data. We need to know more about this $12.7 trillion portfolio's management.

[20] Chițu, et al. (2019) show that ECB FX reserves are in USD, JPY and CNY, See also Silvonen and Port (2020).

Appendix 1: Data definitions and sources

$Val\_Eff_{USD}^{COFER}$: The valuation effect of the USD, defined as:

$$\frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t-1)}}$$

where R_C is reserves, claimed in major currency c. FX_C is the value of major currency c per dollar. The reserve data are extracted from the IMF's COFER database. The exchange rate data is from the IMF *International Financial Statistics (IFS)*.

$Val\_Eff_{USD}^{SNB}$ is computed in the same way, but uses the data from SNB's database https://data.snb.ch/en/topics/snb#!/cube/snbcurrp.

$Val\_Eff_{USD}^{SNB}$ is analogous to $Val\_Eff_{USD}^{IM}$, but uses the data from Ito and McCauley (2020). Unlike the previous two valuation effects variables, this variable is not only time-variant but also variant across countries.

Total reserve assets net of the exchange rate effects are calculated using the following formula:

$$\frac{\mathrm{R}_{USD}(\mathrm{t})}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t})}{FX_c(t-1)}} - \frac{\mathrm{R}_{USD}(\mathrm{t}-1)}{\sum_c^C \frac{\mathrm{R}_c(\mathrm{t}-1)}{FX_c(t-1)}}$$

VIX is the Chicago Board Options Exchange's (CBOE) Volatility Index, which is used as the measure of global financial instability. The index is available at: https://www.cboe.com/indices/ .

NEER is the narrow nominal effective exchange rate, published by the Bank for International Settlements (BIS).

IR_G is the variable for FX reserves minus gold as a share of GDP. The data is extracted from the World Bank's *World Development Indicators*.

Appendix 2: Country list (56 economies) for the panel analysis

Asia & Pacific (9): Australia[AE], Bangladesh, Hong Kong SAR, China[AE], India, Korea, Rep.[AE], New Zealand[AE], Papua New Guinea, Philippines, Sri Lanka

Western Europe (6): Denmark[AE], Iceland[AE], Norway[AE], Sweden[AE], Switzerland[AE], United Kingdom[AE]

Eastern Europe and Central Asia (17): Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic[AE], Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia, Tajikistan, Turkey, Ukraine

West Hemisphere (12): Argentina, Bolivia, Brazil, Canada[AE], Chile, Colombia, Costa Rica, Ecuador, Paraguay, Peru, Uruguay, Venezuela, RB

Africa and Middle East (12): Ghana, Israel[AE], Kenya, Malawi, Mozambique, Namibia, Nigeria, South Africa, Tanzania, Tunisia, Uganda, Zambia

Notes: "AE" stands for "advanced economies" whereas the rest of the countries are "emerging market and developing economies." The definitions are based on the IMF categorisation.

References:

Amiti, M., & Weinstein, D. E. 2011. Exports and financial shocks. The Quarterly Journal of Economics, 126(4), 1841-1877.

Aizenman, J., H. Ito, and G. K. Pasricha. 2021. "Central Bank Swap Arrangements in the COVID-19 Crisis," mimeo.

Baker, Scott R., N. Bloom, S. J. Davis. 2016. Measuring Economic Policy Uncertainty, The Quarterly Journal of Economics, Volume 131, Issue 4, November: 1593–1636.

Baker, S., Bloom, N., Davis, S., Kost, K., Sammon, M. and Viratyosin, T, 2020. The Unprecedented Stock Market Impact of COVID-19, NBER Working Paper #26945.

Backus, D. K., and J. H. Wright. 2007. Cracking the Conundrum. Brookings Papers on Economic Activity 1: 293–329.

Beck, R., Weber, S., 2011. Should larger reserve holdings be more diversified? Int. Fin. 14 (3), 415–444.

Bernanke, B., V. Reinhart, and B. Sack. 2004. "Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment." Brookings Papers on Economic Activity 2: 1–100.

Blanchard, O, F Giavazzi, P Sa 2005. International Investors, the U.S. Current Account, and the Dollar, Brookings Papers on Economic Activity, 1:2005, 1-65.

Bordo, M., & McCauley, R. 2019. Triffin: Dilemma or myth? IMF Economic Review, 67(4), 824–851.

Borio, C., Galati, G., Heath, A., 2008. FX reserve management: trends and challenges. BIS Papers no 40.

Borio, C., McCauley, R., McGuire, P. 2017. FX swaps and forwards: missing global debt? BIS Quarterly Review, September: 37-54.

Camanho, N., Hau, H., Rey, H. 2020. Global Portfolio Rebalancing and Exchange Rates, CEPR DP15617, December.

Cappiello, L., and De Santis, R. 2005. Explaining Exchange Rate Dynamics: The Uncovered Equity Return Parity Condition. ECB Working Paper 529.

Cappiello, L., and De Santis, R, 2007. The Uncovered Return Parity Condition. ECB Working Paper 812.

Chinn, M. 2015. How much more dollar appreciation? Econbrowser, 13 April.

Chinn, M., Frankel, J., 2005. Will the euro eventually surpass the dollar as leading international reserve currency? NBER Working Paper No. 11510.

_____. 2007. Will the euro eventually surpass the dollar as leading international reserve currency? In: Clarida, R. (Ed.), G7 Current Account Imbalances: Sustainability and Adjustment.

University of Chicago Press, Chicago, pp. 285–323.

Chiţu, L., Gomes, J., Pauli, R., 2019. Trends in central banks' foreign currency reserves and the case of the ECB, ECB Economic Bulletin, Issue 7/2019.

Curcuru, S., Thomas, C., Warnock, F., Wongswan, J. 2014. Uncovered Equity Parity and Rebalancing in International Portfolios. Board of Governors of the Federal Reserve System, International Finance Discussion Papers, Number 1103, May.

Dooley, M. 1987. An analysis of the management of the currency composition of reserve assets and external liabilities of developing countries. In R Aliber, ed, The reconstruction of international monetary arrangements, Basingstoke, Hampshire: Macmillan, pp 262-280.

Eichengreen, B and D Mathieson. 2000. "The currency composition of foreign exchange reserves: retrospect and prospect", IMF Working Papers, no 00/131, July.

Engel, C. and Hamilton, J. 1990. Long swings in the dollar: are they in the data and do markets know it? American Economic Review, vol 80, no 4, September: 689-713.

Federal Reserve Bank of New York, 2021. Treasury and Federal Reserve Foreign Exchange Operations, September-December 2020, 11 February.

Fischer, A., Greminger, R., Grisse, C., Kaufmann, S. 2021. Portfolio rebalancing in times of stress J. of International Money and Finance, Volume 113, May, 102360.

Fratzscher, M., 2009. What explains global exchange rate movements during the financial crisis? Journal of International Money and Finance 28, 1390–1407.

Friedman, M. 1953. "The Case for Flexible Exchange Rates." In Essays in Positive Economics. Chicago: University of Chicago Press.

Gerlach-Kristin, P., McCauley, R., Ueda, K. 2016. Currency intervention and the global portfolio balance effect: Japanese lessons, J. of Japanese and the Int'l Economies, vol 39: 1-16.

Gopinath, G., Stein, J., 2018. Banking, trade, and the making of a dominant currency. NBER Working Paper Series no 24485. National Bureau of Economic Research.

Gopinath, G., Stein, J., 2018b. Trade invoicing, bank funding, and central bank reserve holdings. Am. Econ. Rev. 108 (May), 542–546.

Harvey, C., Rattray, S., and Van Hemert, O. 2021. Strategic risk management, Hoboken, NJ, Wiley.

Hau, H., and Rey, H. 2006. Exchange rates, equity prices, and capital flows, Review of Financial Studies 19.1: 273-317.

Hauck, O, Truman, E. 2015. China and the IMF: The IMF Blinks, China Economic Watch, Peterson Institute for International Economics, November 5.

Heller, H and M Knight. 1978. "Reserve currency preferences of central banks", Princeton Essays in International Finance, no 131, December.

Iancu, A., Anderson, G., Ando, S., Boswell, E, Gamba, A., Hakobyan, S., Lusinyan, L., Meads,

N., Wu, Y., 2020, Reserve Currencies in an Evolving International Monetary System, IMF Departmental Paper 2020/002, 17 November.

Ito, H., McCauley, R, 2020. Currency composition of foreign exchange reserves, J. of Int'l Money and Finance, vol 102:

Ito, H., McCauley, R., Chan, T. 2015. Emerging market currency composition of reserves, denomination of trade and currency movements, Emerging Markets Rev., December: 16-29.

Ivanova, Y., Neely, C., Weller, P., Famiglietti, M. 2021. Can risk explain the profitability of technical trading in currency markets. J. of International Money and Finance, Volume 110, February, 102285.

Johnson, H. G. 1969. The Case for Flexible Exchange Rates, 1969. Federal Reserve Bank of St. Louis Review, June: 12-24.

Johnson-Calari-, J. and Stauss-Kahn, I. 2020. Good governanceé principles, pitfalls and best practice, in J. Bjorheim, ed, Asset management at central banks and monetary authorities, Cham, Switzerland: Springer Nature: 305-321.

Jones, B. 2018. Central bank reserve management and international financial stability – some post-crisis reflections, IMF Working Papers, WP/18/31, February.

Kindleberger, C 1937. International Short-term Capital Movements. New York: Columbia University Press.

Kreicher, L. and R. McCauley. 2021. Managing the dollar over its cycles, paper to be presented to a plenary panel, Managing the dollar, 91st International Atlantic Economic European Conference, 19 May.

Liang, N., P. Parkinson. 2020. Enhancing liquidity of the U.S. Treasury market under stress, Hutchins Center on Fiscal and Monetary Policy at Brookings Working Papers no 72, 16 December.

Lu, Y and Y Wang. 2019. Determinants of Currency Composition of Reserves: a Portfolio Theory Approach with an Application to RMB, IMF Working Paper WP/19/52, March.

McCauley, R. 2017. Global bond market spillovers from monetary policy and reserve management, in A Ghosh and M Qureshi, eds, From Great Depression to Great Recession: the elusive quest for international policy cooperation, Washington: IMF: 147-66

McCauley, R. 2020. Safe assets and reserve management, in J. Bjorheim, ed, Asset management at central banks and monetary authorities, Cham, Switzerland: Springer Nature: 131-150.

McCauley, R and T Chan. 2014. "Currency movements drive reserve composition", BIS Quarterly Review, December: 23-36.

McCauley, R.N. and McGuire, P.. 2009. Dollar appreciation in 2008: safe haven, carry trades, dollar shortage and over-hedging. BIS Quarterly Review 85–93.

McCauley, R. and Rigaudy, J-F. 2011. Managing foreign exchange reserves in the crisis and after, in Portfolio and risk management for central banks and sovereign wealth funds, BIS Papers no 58, October: 19-47.

Mehrling, P. Forthcoming.Money and empire: Charles P. Kindleberger and the dollar system, Cambridge: Cambridge University Press.

Melvin, M., Prins, J.2015. Equity hedging and exchange rates at the London 4 p.m. fix. J. of Financial Markets, Volume 22, January: 50-72.

Menkhoff, L., Sarno, L., Schmelinga, M., Schrimpf, A. 2012. Currency momentum strategies. J. of Financial Economics, Volume 106, Issue 3, December, 660-684.

Młynarski, Feliks. 1929. Gold and Central Banks. New York: Macmillan.

Moskowitz, T, Ooi, Y., Pedersen, L. 2012. Time series momentum. J. of Financial Economics, Volume 104, Issue 2, May: 228-250.

Neely, C. 2011. A Foreign Exchange Intervention in an Era of Restraint. Federal Reserve Bank of St. Louis Review, September/October, 93(5): 303-24.

Neely, C., Weller, P., Ulrich, J. 2009. The Adaptive Markets Hypothesis: Evidence from the Foreign Exchange Market. Journal of Financial and Quantitative Analysis, Volume 44 Issue 2, April: 467 – 488.

Nurkse, R. 1944. International Currency Experience: Lessons of the Inter-War Period. Geneva: League of Nations.

Pihlman, J., van der Hoorn, H. 2010. Procyclicality in Central Bank Reserve Management: Evidence from the Crisis. IMF Working Paper No. 10/150, August.

Potter, S., Nemeth, M., Choi, M. 2020. Central banks as bankers to each other: overview, trends, and future directions in global official sector service provision, in J. Bjorheim, ed, Asset management at central banks and monetary authorities, Cham, Switzerland: Springer Nature: 355-381.

Sack, B., McNeil, K. 2011. Treasury and Federal Reserve Foreign Exchange Operations, January-March 2011. Federal Reserve Bank of New York Quarterly Report, April.

Sarin, R., Singh, S. 2015. RBI: Raise share of dollar in foreign exchange reserves: Strategy panel makes push as other currencies underperform, The Indian Express, 9 January.

Schanz, J. 2019. Foreign exchange reserve management: trends and challenges, in Reserve management and FX intervention, BIS Papers no 194, 31 October: 45–55.

Silvonen, T., Port, E., 2020. European Central Bank: the investment decisions-making process and its governance, in in J. Bjorheim, ed., Asset management at central banks and monetary authorities, Cham, Switzerland: Springer Nature: 189-207.

Streit, S and P Muhl. 2020. The Swiss National Bank's Investment Decision-Making Process from

a Safe-Haven Currency Perspective, in J. Bjorheim, ed., Asset management at central banks and monetary authorities, Cham, Switzerland: Springer Nature: 225-244.

Swiss National Bank (SNB). 2011, 2018. Annual Report, 2010, 2017. Zurich: SNB.

Tille, C. 2003. The Impact of Exchange Rate Movements on U.S. Foreign Debt, Federal Reserve Bank of New York Current issues in Economics and Finance, Volume 9, Number1, January.

Triffin, R. 1960. Gold and the dollar crisis: The future of convertibility. New Haven, CT: Yale University Press.

Truman, E., Wong, A., 2006, The Case for an International ReserveDiversification Standard, Peterson Institute for International Economics, Working Paper 06, 2 May.

Warnock, F. E., and S. C. Warnock. 2009. International Capital Flows and U.S. Interest Rates. Journal of International Money and Finance 28: 903–19.

Williams, J. 1934. The World's Monetary Dilemma—Internal versus External Stability. Proceedings of the Academy of Political Science 16 No. 1 (April): 62-68. Reprinted as Ch. 10 in Williams 1944.

Williams, J. 1937. The Adequacy of Existing Currency Mechanisms under Varying Circumstances. American Economic Review 27 No. 1, Supplement (March): 151-168. Reprinted as Ch. 11 in Williams 1944.

Williams, J. 1944. Postwar Monetary Plans and other essays. New York: Knopf.

Table 1: Regression of USD shares on valuation effects, using SNB data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
USD valuation effect (VE)	-0.147	-0.099	0.016	-0.111	0.901	-0.106	-0.003
	(0.238)	(0.233)	(0.248)	(0.234)	(1.873)	(0.240)	(0.332)
Growth rate of FX assets		-0.024		-0.027	-0.023	-0.023	-0.023
		(0.012)**		(0.012)**	(0.012)*	(0.012)*	(0.012)*
VE x asset growth			-0.019				
			(0.010)*				
VIX in log				0.474			
				(0.518)			
VE x VIX					-0.338		
					(0.628)		
NEER apprec. period						0.053	
						(0.366)	
VE x NEER app							-0.196
							(0.476)
N	63	63	63	63	63	63	63
Adj R2	0.42	0.45	0.44	0.45	0.44	0.44	0.44
H0: beta (VE) =1 (p-value)	0.00	0.00	0.00	0.00	0.96	0.00	0.00

Note: * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

Table 2: Testing trends in the USD shares

	Full sample		2002Q1 – 2011Q3		2011Q3 – 2020Q1	
	USD share w/ VE (1)	USD share w/out VE (2)	USD share w/ VE (3)	USD share w/out VE (4)	USD share w/ VE (5)	USD share w/out VE (6)
Quarter	-0.106	-0.063	-0.185	0.021	-0.003	-0.155
	(0.009)***	(0.006)***	(0.014)***	(0.016)	(0.028)	(0.013)***
N =	88	88	38	39	35	35
Adj R2	0.62	0.60	0.81	0.02	-0.03	0.81

Table 3: Regression of USD shares on valuation effects, using COFER data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
USD valuation effect (VE)	0.710 (0.062)***	0.724 (0.061)***	0.791 (0.096)***	0.724 (0.061)***	-0.438 (0.575)	0.716 (0.063)***	0.751 (0.080)***
Growth rate of FX assets		0.048 (0.020)**		0.048 (0.021)**	0.051 (0.020)**	0.050 (0.021)**	0.048 (0.021)**
VE x asset growth			-0.034 (0.030)				
VIX in log				0.011 (0.170)			
VE x VIX					0.387 (0.191)**		
NEER apprec. period						0.059 (0.120)	
VE x NEER app							-0.067 (0.129)
N	87	87	87	87	87	87	87
Adj R2	0.60	0.62	0.60	0.62	0.63	0.62	0.62
H0: beta (VE) =1 (p-value)	0.00	0.00	0.03	0.00	0.01	0.00	0.00

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 4: Determinants of Change in the USD Share in FX Reserves: 2001-2018, using the Ito-McCauley data

	F.E.	F.E.	F.E.	F.E.	F.E.	F.E.	F.E.	WEIGHTED
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
USD Valuation Effect (VE)	0.522	0.788	0.955	0.771	0.763	0.783	0.637	0.153
	(0.258)**	(0.262)***	(0.294)***	(0.263)***	(0.263)***	(0.265)***	(0.435)	(0.203)
Growth rate of FX assets		0.044	0.044	0.044	0.044	0.044	0.044	0.028
		(0.008)***	(0.008)***	(0.008)***	(0.008)***	(0.008)***	(0.008)***	(0.012)**
Growth rate of FX assets x VE			-1.102					
			(0.883)					
Change in VIX				-0.000				0.000
				(0.001)				(0.001)
dVIX x VE					-0.049			
					(0.052)			
FX reserves minus gold (% of GDP)						0.005		
						(0.038)		
FX reserves x VE							0.949	
							(2.185)	
N	733	721	721	721	721	718	718	721
# of countries	56	56	56	56	56	56	56	56
Overall R2	0.01	0.06	0.06	0.06	0.06	0.06	0.06	0.04
W/in R2	0.01	0.05	0.05	0.05	0.05	0.05	0.05	0.01
B/w R2	0.10	0.21	0.22	0.21	0.22	0.21	0.22	0.16
H0: beta (VE) =1 (p-value)	0.06	0.42	0.88	0.39	0.37	0.41	0.40	0.00

Table 5: Determinants of Change in the USD Share in FX Reserves: 2001-2018

Using the Ito-McCauley dataset, AEs and EMEs

	AEs	EME	COMM	Non-COMM
	(1)	(2)	(3)	(4)
USD Valuation Effect (VE)	-0.135	1.426	1.062	0.655
	(0.294)	(0.353)***	(0.543)*	(0.300)**
Growth rate of FX assets	-0.041	0.057	0.045	0.043
	(0.017)**	(0.010)***	(0.012)***	(0.013)***
Change in VIX	-0.000	-0.000	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
N	178	543	211	510
# of countries	13	43	15	41
Overall R2	0.04	0.10	0.08	0.04
W/in R2	0.04	0.09	0.08	0.03
B/w R2	0.04	0.25	0.14	0.37
H0: beta (VE) =1 (p-value)	0.00	0.23	0.91	510

Note: * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Figure 1(a): US FX reserves in euro and yen

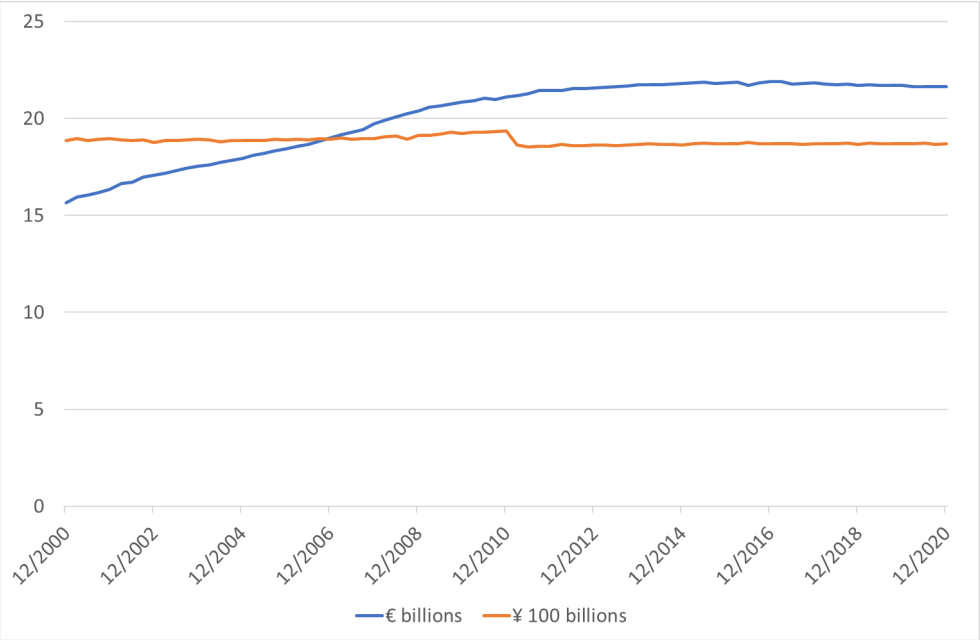


Figure 1(b): The euro share of US reserves

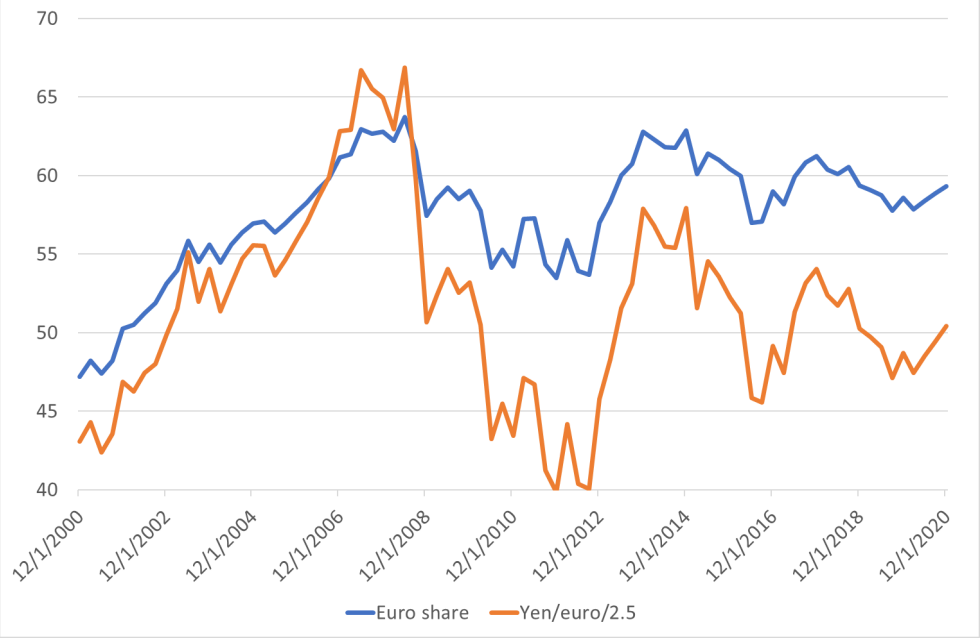


Figure 1(c): Euro share, valuation effect and rebalancing of US FX reserves, in percent

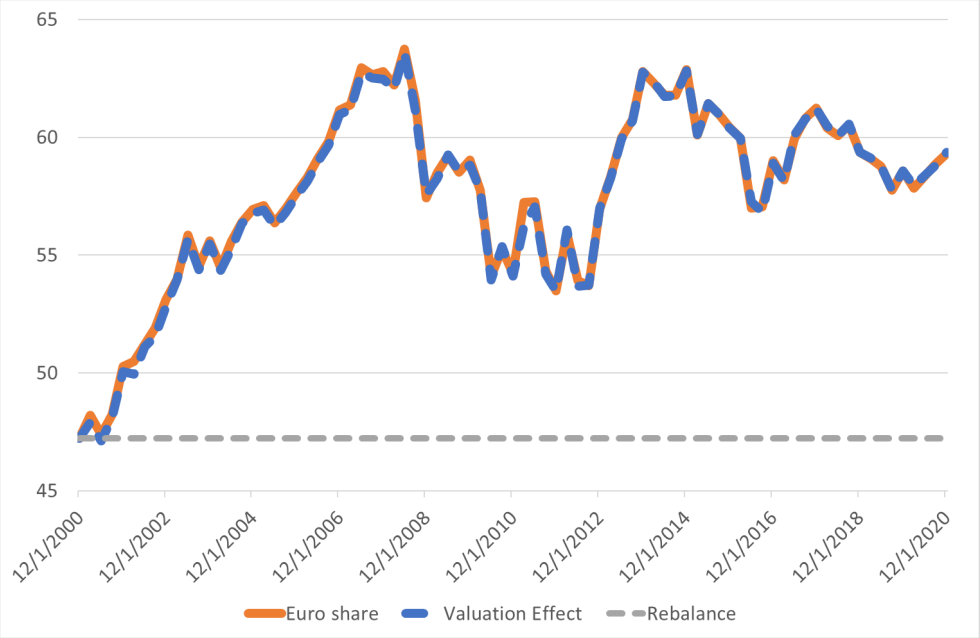
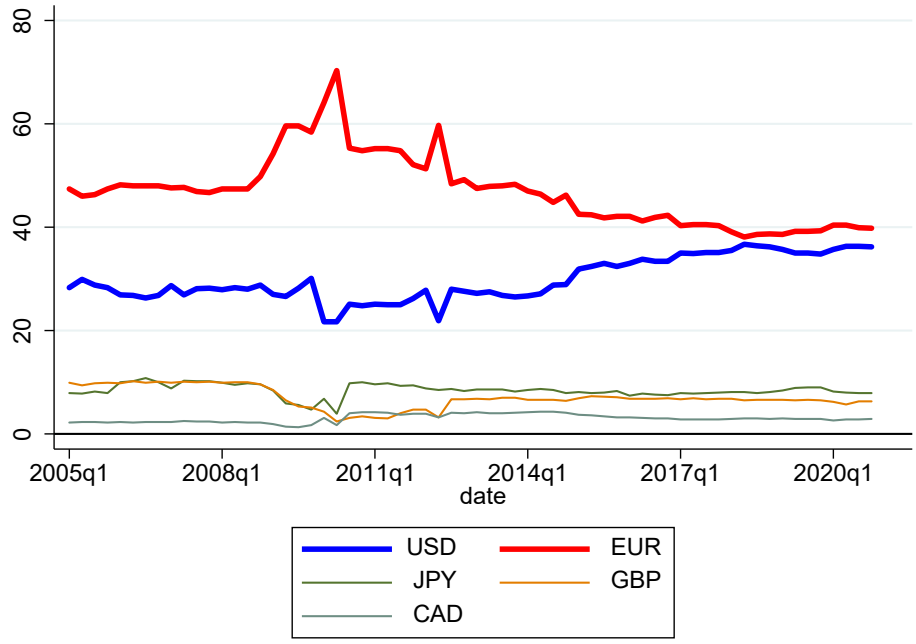
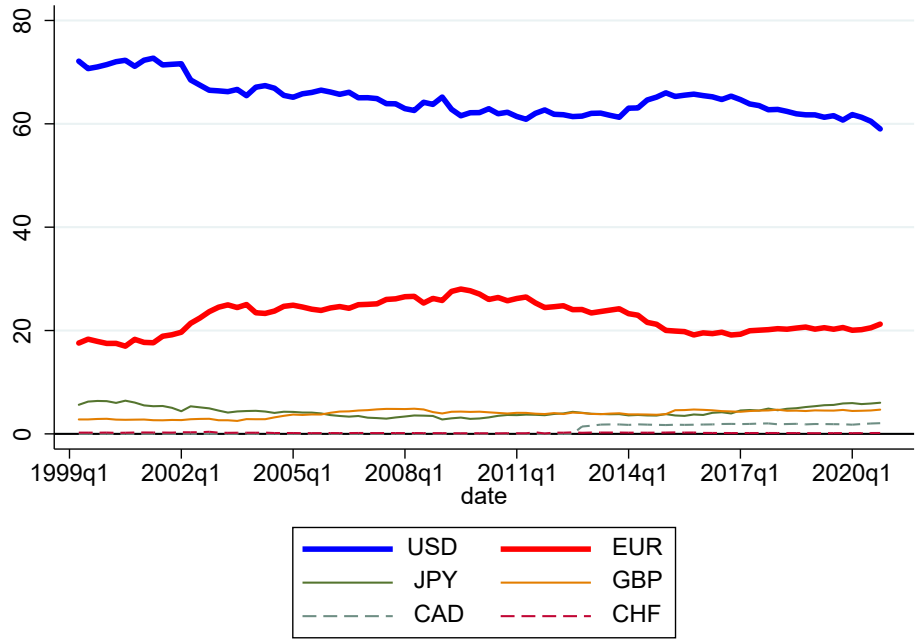


Figure 2: Currency composition of SNB's reserve assets, 2005Q1 – 2020Q4



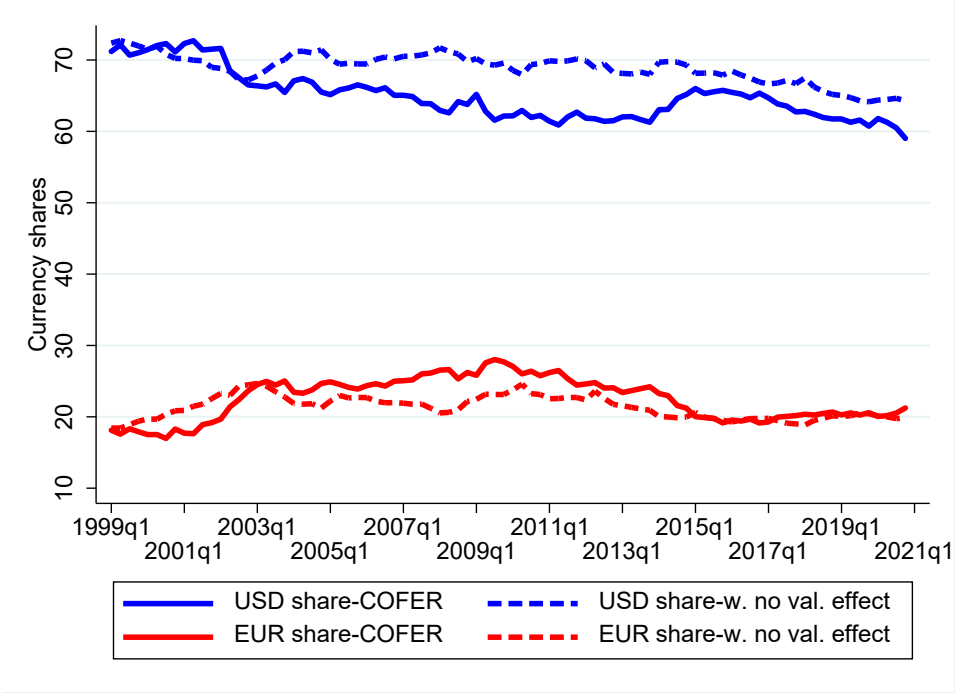
Source: Swiss National Bank. https://data.snb.ch/en/topics/snb#!/cube/snbcurrp

Figure 3: Shares of major currencies – COFER dataset



Source: International Monetary Fund (IMF) COFER database

Figure 4: Share of USD and EUR in FX reserves with and without valuation effects



Sources: IMF COFER database and authors' calculations.

Figure 5

(a): Share of USD in FX reserves (COFER) with and without valuation effects

(b): US NEER

Sources: IMF COFER database, BIS, and authors' calculations.

Note: The dotted lines correspond to 2002m2, 2011m7, and 2020m4.